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the relative dates of the Kansan, Illinoian, Iowan and Wisconsin glaciations. But on this question scarcely more than a very rude approximation is likely to be reached. As indicated above, the work involved in filling is especially difficult to determine. These difficulties, however, are no greater than those involved in the estimates of the changes of drainage area which the Mississippi has experienced. The object of the present paper is accomplished if the complexity of the history has been adequately presented. The chronological determinations must be deferred to a time when more refined methods of investigation are instituted than are now at command.

OBSERVATIONS ON THE GEOLOGY OF STEAMBOAT SPRINGS, COLORADO.

BY F. M. WITTER.

In the year 1873, a division of geologists under the management of Dr. F. V. Hayden, made a survey of the region from Willow Creek pass, between North and Middle Parks, across the park range down the Yuma or Bear river to the White river, around to Eagle river and up the Grand, of which Willow creek, in Middle Park, is a tributary. In this report, very brief mention is made of Steamboat Springs, although the trail on their map does not pass nearer than twenty-five or thirty miles to the Springs.

Steamboat Springs is now not far from 100 miles by wagon road from a railway. Rawlins, on the Union Pacific in Wyoming, is probably the nearest railroad point on the north, and Glenwood Springs, on the Denver & Rio Grande, is the nearest on the south. Last July our party left North Park in its extreme southwest corner at Rabbit Ear peak. This mountain is the most conspicuous in the park range, immediately west of North Park. From near Pinkhampton, in the northeast corner of North Park, Rabbit Ear is plainly visible, a distance of sixty miles or more. This peak is capped by two immense vertical rocks about 100 feet apart. These rocks have suggested the name for the peak. By means of a spruce-tree ladder we climbed to the top of one of these huge "ears." We

could then see the whole of North Park, and much country in every direction, probably, in all, 4,000 square miles.

It is worth a trip to Colorado to stand on the top of Rabbit Ear. In North Park we had found scoriaceous rock, which called to mind forcibly the thought that a volcano was not far away. In ascending Rabbit Ear it soon became apparent we were on the very cone itself. Along the sides, in great profusion, were fragments of scoria, with occasional slag-like masses. These continued to the top, where the two great ears seemed to be firmer, more like trap, though not entirely uniform, some portions weathering away much faster than others. We had no means of determining our altitude at this point, but from the snow about us (this was July 12th,) and the Alpine vegetation, it must have been about 12,000 feet. Steamboat Springs is northwest of Rabbit Ear about eighteen miles. The pass here, at this time, was completely dry, but a little earlier it is very muddy, almost impassable. On reaching the western edge of the Park range, about seven miles east of the Springs, it seemed as if we had come to a jumping-off place. Far below us we could see the Bear with its beautiful valley, green fields of oats and timothy, the little log houses of the pioneers, and to the right in the distance, nestled at the foot of this great mountain range, lay the village, Steamboat Springs. The Yampa or Bear river here runs west from Egeria Park, but at the Springs it turns south.

The mountains to the south of the Bear appear to be much lower, and differ in many respects from the Park range just to the north There is not that boldness, that ruggedness, although separated only by the narrow valley of the Bear. The student of geology could not fail to be impressed with this difference, as he stands at this point on the southern edge of the Park range. On descending the mountain but few extensive rock exposures are seen. Most, if not all, of the rocks show metamorphism, being derived from what seems to have been some kind of sandstone or argillaceous shales. No marble was noticed in this locality. On the north side of the Bear river, in the valley three or four miles east of the Springs the region is thickly covered with well rounded granitoid bowlders, some of which are ten to twenty feet through. These have come from the mountains close by on the north. The bed and banks of Fish creek are a mass of bowlders, with very little filling between them. This is a

pretty mountain stream, which has its sources in the great range just north of this valley, and joins the Bear a mile east of the Springs. Some four miles up, this creek has made for itself a wild, deep gorge or cañon, and here, in 200 or 300 yards, it falls perhaps 200 feet. In this cañon great masses of rock lie in every position and these show plainly a bedding, although the main walls of this cañon are almost vertical sheets of metamorphic rocks.

At a point some six or seven miles northwest of Steamboat Springs, at some springs we visited, the temperature of the water is said to be about 160 degrees F. The rocks are, in part, at least, very dark colored, compact and fine grained, resembling diorite. Enough has been said to show that the Park range, immediately north of Steamboat Springs, is largely metamorphic, abounding in granites, syenites and volcanic rocks. In this vicinity the valley of the Bear is from one-half mile to a mile in width. Directly opposite the village, which is almost wholly on one street on the north side of the river, is a rather lofty and rugged mountain, but for the most part the country on the south side of the Bear is much less precipitous and is not covered by timber like the mountains close on the north. The valley here has undoubtedly been the seat of an immense glacier, which was well supported from the north by great numbers of glaciers lying on the southern face of Park range.

One very conspicuous moraine lies in the village, and to improve the single straight street this moraine has been cut transversely. In the village there are four charming little creeks, all coming from the mountains on the north. Not a single creek enters the Bear river, for several miles, from the south. Opposite the eastern or upper end of the village, some 300 feet above the valley of the river, is an "onyx mine." Here a horizontal tunnel has been carried perhaps 200 feet into the side of the mountain. A cross section of this tunnel is not less than six feet square. It is perfectly dry and is wholly in what seems to be unmodified drift. The onyx is scattered through this drift in pieces varying from a cubic inch to blocks three or four feet square and eight or ten feet long. These pieces show, in many cases, unmistakable evidence of erosion or weathering, and they are so packed in with the clay and granite pebbles that we could hardly pull out small pieces from the walls of the tunnel. How extensive the

onyx deposit here may be, we could not determine, but there are some reasons for believing the material to be abundant. Its geological history, at present, is not altogether clear, but it may be assumed that all such limestone formations have been formed in caves. The cave or caves where this was formed must have been near by, for the fragments are of such shape as to show but little abrasion from ice or water. The cave seems to have been crushed by the glacier, crowded up against the side of the mountain and left there without any further disturbance. It seems probable that the scene of the action of the glacier must have been mainly lower down towards the foot of the mountain, otherwise this soft onyx would have been reduced to limestone mud. It also seems very probable that caves, in which this onyx forms or grows, no longer exist in this region, unless it might be a short distance to the west from the present mine, where heavy deposits of calcium carbonate exist and where such deposits are now forming. Where this supply of material, necessary to form the onyx and soft, limy hills, near by, was obtained, we did not discover, but there must be limestone in the mountain not far away.

At the extreme western end of this long valley, which is about one-half mile long, and a few rods west of Soda creek, is a fine spring of moderately cool water, supersaturated with carbon dioxide. This spring is in the midst of a flat area of several acres, much of which shows plainly that springs once existed almost everywhere over it, and now, only a dozen rods away, are large springs yielding an abundance of hydrogen sulphide, the odor of which may frequently be detected a quarter of a mile distant. The "soda spring," as it is called, referred to above, issues now through a round hole about one foot in diameter, in a heavy block of sandstone. The spring is covered by a neat pavilion, ten or twelve feet square, with comfortable seats around the inside. It is a general resort for campers at the springs. The carbon dioxide comes up in great bubbles and the water is delightfully acid There is no evidence at this spring that the water carries any limestone with it. Along the banks of the Bear, near by (this spring is probably ten to fifteen rods from the river), were thin, soft, shelving rocks, of what are supposed to be calcium carbonate, four or five feet in total thickness. On the south side of the river were rounded hills twenty feet or more in height and of

considerable extent; in one case an acre or more of this same soft rock, evidently formed by the springs. One spring is heavily charged with iron; another is called milk spring, soda spring, sulphur spring, etc., all within easy distance of each other. Some springs have a sort of periodic flow.

Particularly is this true of one which sounds very much like the puffing of a steamboat.

At the eastern end of the village is a spring issuing from fissures in what seems to be a volcanic rock. The water of this spring has a temperature of 108 degrees F. Close by this spring is a very neat and convenient bath house, with nice large pools for swimming. The water here is abundant, and, at first, seems almost too hot for comfort, but it soon becomes delightful. It contains a small amount of hydrogen sulphide. Seven miles northwest of the village, in a very wild and unfrequented region, we visited what are known at the Springs as the Hot Springs. Here the water has a temperature of 160 degrees F., so we were told; we forgot our thermometer at Ft. Collins. In about twenty minutes it cooked eggs for us. These springs are within a rod or two, on either side, of a delightful little mountain stream. They issue from fissures in a dark, fine-grained rock, already referred to as resembling diorite, or basalt. In one of the hills mentioned above, formed by the springs by the Bear, is a small cave. On descending into this cave, I had my first serious encounter with carbon-dioxide. It was wholly unexpected, and for a few moments I could not realize why I could not breathe. Other members of our party went into the cave, cautiously, to convince themselves that there was an unbreathable gas present. In the bottom of this cave is an incrustation of what appears to be sulphur.

There are abundant reasons for believing that the springs in and around this village are on the decline. Places where springs must have been strong and vigorous, in very recent geologic time, now show no signs of life. Such places are numerous. How rapidly such changes are taking place here now, we did not attempt to determine.

Steamboat Springs is probably a little over 6,000 feet above the sea. Every night, while we were camped at the village, water froze in our buckets, and particularly, on the morning of July 24th, so much ice was formed in our buckets and about our mess box, that, judging from like conditions at Muscatine,

the temperature must have been close to 20 degrees F. Apparently tender vegetation—beautiful wild flowers—seem to laugh at these little touches of winter, and likewise, in the Hot Springs where the water boiled eggs in twenty minutes, at least one alga grows in considerable abundance.

THE DISTRIBUTION OF LOESS FOSSILS.

BY B. SHIMEK.

It has perhaps been noted that the loess molluscs thus far reported in the literature of the subject are, for the most part, from localities in close proximity to larger streams. This fact may have suggested the thought to those unfamiliar with the modern habits and present distribution of these molluscs that the adjacent streams had in some way something to do with the entombing of the shells now found in the loess. That the loess is most richly fossiliferous near streams is generally, though not always, true. The abundance of fossils is a decidedly variable quantity. There are exposures near streams which exhibit fossils in profusion,and others which are wholly barren. On the other hand, exposures quite remote from streams contain fossils,—though in such situations a proportionately much larger part of the loess is entirely devoid of them.

This fact has sometimes led geologists to attempt to distinguish, in varying degrees, between the loess adjacent to streams and loess more remote. Whatsoever distinction may be observed in the physical character of the loess of various deposits,* no distinction can be based on the presence or absence of fossils alone. The simple fact that one deposit is fossiliferous and another is not, does not prove, nor even indicate, that the deposits were formed under wholly, or even materially, different circumstances. In the one case there are no fossils, simply because there were no shells to be buried; in the other, fossils are common because shells were abundant on the old land surfaces, where they were covered as other imperishable objects would have been covered.

*For one of the most recent discussions of the loess, with reference to its variation according to distance from streams, see Doctor Chamberlin's article in the Journal of Geology, Vol. V, No. 8, p. 795.